Opening the Earth Simulator Project

The Earth Simulator, which was completed in February, 2002 after five years' development, is a highly parallel vector supercomputer system consisting of 640 processor nodes connected by high performance interconnection network switch system. It achieved 35.86 Tflops in LINPACK benchmark test in April 2002 and, much more surprisingly, 26.58 Tflops (65% of the peak value of 40.92 Tflops) by the AFES code, a global atmospheric circulation code which was carefully optimized for the Earth Simulator architecture.

Yearly program, resource allocation, project selection rules, and review are determined by the Mission Definition Committee and recommended to the director of the Earth Simulator Center. Forty projects are accepted out of 73 proposals in FY2002. Their programs are demanded to optimize beyond a certain level. Because of this control the overall performance is now exceeding on the average 30% of the peak value.

The Earth Simulator Research Project started in the middle of July, 2002 and many epoch-making results have been produced already in the end of March 2003, such as Kuroshio, Gulf stream and Agulhas rings in global oceanic circulation; typhoons and rain fronts in global atmospheric circulation; reproduction of the Nankai Earthquake in 1944; super-diamond material of carbon-nano-tubes. Gearing the Earth Simulator Project to the second year, let me here emphasize the mission of the Earth Simulator.

In the past, simulations broke down the whole into parts or stages to extract individual nonlinear phenomena and then reduce them to idealized problems. The role of the simulation has been the nonlinear solver of these idealized problems. This sort of nonlinear solver has played a decisive role in the accomplishments of modern Western Science, which is based on the theory of reductionism. However, as long as simulations are held to the realm of nonlinear solvers, they will not be able to go beyond merely providing support for findings from experiments and observations. Computer simulation which comes forth as a result of using the Earth Simulator, has potential to go far beyond the passive role of backing up observations or data measurements to play a truly active role. They possess the capacity for consistently dealing with an entire system - we call this, "a holistic simulation", and the Earth Simulator may become the world's first means of achieving the holistic simulation. This holistic simulation is a virtual means for revealing the true essence of a nonequilibrium/ nonlinear/ open system, an area which has been left unexplored by the 20th century science.

For instance, a novel and revolutionary technological development upon which the future of mankind depends, such as development of nuclear fusion reactors, must undergo many expensive trial and error experiments at each stage of the development process. In the case of innovative technological development for cars or rockets, for example, where there is always a push for improvements, holistic simulations can play a huge role by reducing the number of tests needed or pointing the course of development in the proper direction. In that sense, clearly holistic simulations could have huge impacts on reducing costs for and improving efficiency of revolutionary technological developments.

Also the same kind of impact by holistic simulation will greatly enhance the development of global warming simulations to make accurate predictions about the state of the planet on a more global scale and further into the future normality. The day will come when, even in the world of science and technology, understanding of complex systems will become ordinary. And then, someday we will graduate from our current linear, simplistic thinking where decisions about our actions and thoughts are influenced merely by things in our immediate vicinity and events that will have an effect on our lives tomorrow or perhaps the day after. A day will come when it will feel perfectly natural for our decisions about our actions and thoughts to be influenced by feedback from things far from us and events far in the future. To put it another way, the paradigm will shift naturally to nonlinear complex thinking.

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